HAS THE PRICE BEHAVIOR OF MAJOR MIDWESTERN FIELD CROPS CHANGED AFTER THE FARM POLICY REFORMS OF 1996?

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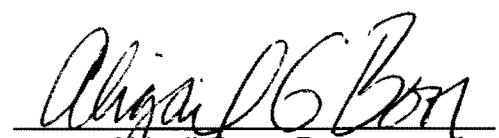
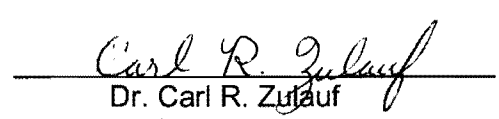


Abigail Grace Boor
AED Economics



Dr. Carl R. Zulauf
Project/Academic Advisor
AED Economics

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Abstract

Objective of this analysis was to examine whether the mean, standard deviation, and correlation of annual U.S. crop year prices for barley, corn, oats, sorghum, soybeans, and wheat has changed after the 1996 farm bill was enacted. The mean, standard deviation, and correlations among these major Midwestern field crops did not differ statistically between three pre-1996 farm bill subperiods identified based on the type of farm policy in effect. The subperiods were crop years 1974/75 through 1981/1982, 1982/83 through 1990/91, and 1991/92 through 1996/97. Thus, these subperiods can be combined in this analysis.

Compared with the 1974/75 through 1996/97 crop years, most mean prices were lower and most standard deviations were smaller during the post-1996 farm period involving the 1997/98 through 2002/03 crop years. Both a t-test and non-parametric rank-sum test found that only the corn and soybean mean annual price was significantly lower during the post-1996 farm bill period. An F-test found that the standard deviations did not differ significantly between the pre- and post-1996 farm bill periods.

Although statistical significance was not found, 11 of 15 correlations were more positive during the post-1996 farm bill period and the average correlation was 29% higher. These correlations bear close watching because, if additional data confirm that they have increased by a statistically significant amount, then the common strategy of reducing risk by using these crops in rotation with each other has declined in value.

Has the Price Behavior of Major Midwestern Field Crops Changed after the Farm Policy Reforms of 1996

Introduction

The *Federal Agriculture Improvement and Reform Act of 1996* was a landmark farm bill. It eliminated annual acreage set aside programs and most government storage programs (Nelson and Schertz, 1996). These two programs had been prominent features of U.S. farm policy since its inception during the Great Economic Depression of the 1930s (Cochrane, 1979; Robinson, 1989; and Tweeten, 1989). Both programs significantly impact the price determination process. Annual acreage set asides limit the number of acres planted to a crop, thus impacting supply and price. Public stock programs increase price when stocks are accumulated, but reduce price when accumulated stocks are released.

A review of the literature finds three studies that addressed whether the behavior of prices has changed in the wake of the 1996 policy changes. The three studies focused on price variability, probably because price variability was an issue of concern following enactment of the 1996 farm bill (e.g., Collins and Glauber, 1998). Each of these studies found that cash price variability has not increased after 1996: (Natcher and Weaver, 2000; Weaver and Natcher, 2000; and Zulauf and Blue, 2003[1]). No study of other characteristics of the price formation process could be located. Of particular interest are the mean price and correlations among annual crop year prices. These attributes, along with price variability, impact profitability, the management of risk, and the cost of government programs.

Given the preceding discussion, the objective of this analysis is to examine whether the mean, standard deviation, and correlation of annual crop year prices for the major Midwestern field crops of barley, corn, oats, sorghum, soybeans, and wheat have changed after the 1996 farm bill was enacted. This study uses an event study approach (MacKinlay, 1997). Because many factors can change between two periods, multiple studies of similar events are needed to

determine if a common explanation emerges for changes observed in the variables being investigated. Since there is only one 1996 farm bill, this event study cannot determine its impact on the price determination process. However, it can address a related and important question: have key attributes of the price determination process changed since the 1996 farm bill was enacted?

The rest of this paper is organized as follows. The next section contains a discussion of the crops and time periods selected for analysis. Discussions of the procedures and results follow. The final section contains conclusions and implications.

Crops and Time Periods Analyzed

This study focuses on the six major field crops grown in the U.S. Midwest: barley, corn, oats, sorghum, soybeans, and wheat. Although sorghum is grown at more southern latitudes and barley and oats are grown at more northern latitudes, these six crops compete with each other in cropping rotations throughout much of the Midwest. In addition, each crop is used in varying degrees as a livestock feed. These production and economic characteristics imply that the annual prices of these crops are likely to be positively correlated.

The analysis begins with the 1974/1975 crop year. This year is commonly used to mark the beginning of a new regime of prices that emerged after the price upheavals of the early 1970s. The upheavals resulted in a move to a higher price level. Key factors included expanding exports due in part to weather related production problems around the world and to the Soviet Union's emergence as an importer of agricultural products (Cochrane, 1979, pp. 153-154), as well as to increasing general inflation highlighted by oil embargoes led by the Organization of Petroleum Exporting Countries.

Price attributes are calculated for the following four time periods: (1) 1974/1975 through 1981/1982 crop years, (2) 1982/1983 through 1990/1991 crop years, (3) 1991/1992 through 1996/1997 crop years[2], and (4) 1997/1998 through 2002/2003 crop years. Examination of

different periods allows a sensitivity analysis of the importance of the changes that may have occurred after the 1996 farm bill. The four subperiods were identified based on the type of farm price and income support programs in existence, with special attention paid to the degree of planting flexibility and level of government stocks. A brief discussion of the farm policy in effect for each of the four subperiods follows.

Throughout the mid- and late-1970s, strong demand growth, especially in exports, and poor growing weather during several years resulted in the infrequent use of annual acreage set asides (U.S. Department of Agriculture (USDA), Farm Service Agency, 2001). However, during the early 1980s stocks began to build as export demand weakened and good production weather occurred. Beginning with the 1982/1983 crop year and continuing through the 1990/1991 crop year, annual acreage set asides for the feed grains and wheat were greater than zero[3]. Other instruments of farm policy during this period for the six Midwestern crops were: (1) nonrecourse loans, which placed a floor under prices; (2) large government stocks, which lasted until the severe drought of 1988; and (3) target price programs, which paid farmers a deficiency payment equal to the difference between the price target established by the farm bill and market price.

Although the *Food, Agriculture, Conservation and Trade Act of 1990* continued the annual acreage set aside program, it also contained what came to be called the flex acre provision. To help reduce the federal budget deficit, the number of program base acres on which a farmer could receive target price deficiency payments was reduced by 15 percent. In exchange for the reduction in public income support, farmers were given the flexibility to plant up to 15 percent of their base acres to another crop without having their base acres reduced. The only crops which could not be planted on flex acres were fruits and vegetables. Farmers also could decide not to plant any crop on the flex acres. The flex acre provision thus gave farmers greater managerial flexibility when making planting decisions[4].

The 1990 farm bill also mandated the use of a marketing loan repayment option for soybeans and other oilseeds, and gave the Secretary of Agriculture discretionary authority to use this option for feed grains and wheat (USDA, Economic Research Service (ERS), 1990)[5]. Subsequently, the Secretary invoked the discretionary authority beginning with the 1993 crops for the feed grains and wheat (Westcott and Price, 2001). In contrast to a nonrecourse loan program, a marketing loan program does not place a floor under price because loans can be repaid at the lower market price. The farmer keeps the difference between the loan rate and market price.

The *Federal Agriculture Improvement and Reform Act of 1996* further increased planting flexibility by eliminating annual acreage set aside programs. It also eliminated most government storage programs and continued the emphasis on marketing loans as opposed to nonrecourse loans (USDA, ERS, 1996). The *Farm Security and Rural Investment Act of 2002* made no changes in the 1996 farm bill's approach to acreage set asides, government storage programs, or marketing loans for the major Midwestern crops (USDA, ERS, 2002)

Procedures

The average annual U.S. crop year cash prices for barley, corn, oats, sorghum, soybeans, and wheat were collected from http://www.nass.usda.gov:81/ipedb/. Means, standard deviations, and Pearson correlations of the annual crop year prices for the six Midwestern crops were computed for each time period. Two measures of standard deviation are calculated because in many situations, including this study, it is debatable whether variability should be measured in absolute or relative terms (Hirschey, 1996, pp. 600-602). Absolute variability is measured as the standard deviation of the level of annual price measured in dollars per bushel. Relative variability is measured as the standard deviation of the change in the natural logarithm (i.e., ln) of annual price. The latter calculation generates a percent measure of price variability.

Means and standard deviations of the different time periods were tested for statistical differences via the commonly used t-test for the difference between two means and the F-test for the difference between two variances (i.e., squared standard deviations). The null hypothesis was that the means (standard deviations) did not differ between the time periods.

Because of the small number of observations, a non-parametric rank sum test also was used to test for differences in the level of annual crop year prices between two periods (Dixon and Massey, 1983). A rank sum test combines the annual price observations for the two time periods being examined, ranks the prices in ascending order, and then tests the resulting ranks to determine if the ranks are randomly distributed between the two time periods or whether the ranks for each time period cluster toward opposite ends of the distribution. The null hypothesis was that the level of price has not changed between the two periods and thus that the ranks were randomly distributed across the two periods.

To illustrate the rank sum test, consider the annual prices for soybeans between the 1991 and 2002 crop years. The price in ascending rank order with their year in parenthesis are: $4.38 (2001), $4.54 (2000), $4.63 (1999), $4.93 (1998), $5.40 (2002), $5.48 (1994), $5.56 (1992), $5.58 (1991), $6.40 (1993), $6.47 (1997), $6.72 (1995), and $7.35 (1996). Clearly, the annual prices for 1997-2002 are highly skewed toward the low end of this distribution while the annual prices for 1991-2002 are highly skewed toward the high end of this distribution. As discussed below, the rank sum test for soybean prices during the 1991/1992-1996/1997 and 1997/1998-2002/2003 periods implies that the prices for these two periods differ at the 95% level of statistical confidence.

To test whether the correlations differ significantly between two periods, a non-parametric sign test is used. A non-parametric test is more appropriate than a parametric test, such as the t-statistic, for two reasons: (1) the small number of correlations between the six crops (i.e., number of observations) and (2) the non-normal distribution of the Pearson correlation that results from the correlation being bounded by -1 and +1.

Pearson correlation measures the linear relationship between two variables. It ranges in value from –1 to +1. A value of +1 means the two variables are perfectly positively correlated. Thus, as one variable increases, the other variable increases by a consistent amount. A correlation of –1 means the two variables are perfectly negatively correlated. Thus, as one variable increases, the other variable decreases by a consistent amount. A correlation of zero implies no linear relationship between the two variables.

The sign test evaluates the directional change in a variable (Hoel, 1971). The variable of interest in this analysis is whether the Pearson correlation for a crop combination increases (i.e., the sign is positive) or decreases (i.e., the sign is negative) between an earlier and a later period. The sign test evaluates whether the signs are randomly distributed between positive and negative or cluster toward positive or negative signs. The null hypothesis is that the Pearson correlations among the Midwestern crops have not changed between the two periods. In other words, the signs are randomly distributed.

Results

The average annual cash prices for the 1974/1975 through 2002/2003 crop years are presented in Figure 1 for corn, soybeans, and wheat and in Figure 2 for barley, oats, and sorghum. Table 1 complements these figures by presenting the average and standard deviation of the annual prices for the various time periods examined in this study.

Almost all mean prices were lower during the 1997-2002 period than during the 1974-1981, 1982-1990, and 1991-1996 periods. The one exception was the lower mean price of barley during 1982-1990 than during 1997-2002. Despite the observed skewness toward lower prices during 1997-2002, the number of mean prices that differed by a statistically significant amount at the commonly-used 90% and 95% confidence levels is much smaller. Statistical significance at the 95% level was observed for soybeans when comparing both 1974-1981 and 1991-1996 to 1997-2002, as well as for corn when comparing 1974-1981 to 1997-2002.

Statistical significance at the 90% level was observed for sorghum when comparing 1974-1981 to 1997-2002, for soybeans when comparing 1982-1990 to 1997-2002, and for both corn and wheat when comparing 1991-1996 to 1997-2002.

Statistical tests also were performed on the difference in mean price between the 1974-1981, 1982-1990, and 1991-1996 periods. None of the means for these three periods differed from each other by a statistically significant amount at the 90% confidence level. Given this result, a mean annual price was calculated for the entire pre-1996 farm bill period of 1974-1996. Mean annual price of corn and soybeans was significantly lower at the 95% level of confidence during 1997-2002 than during 1974-1996.

Only two differences were found between the results of the non-parametric rank sum test and the just discussed t-tests. Comparing corn and wheat prices during 1991-1996 to 1997-2002, significance for the rank sum test occurs at the 95% level of statistical confidence instead of the 90% level found with the t-test. Given the similarity of the results, statistically significant outcomes of the rank sum tests were not presented in table 1.

Almost all standard deviations of annual prices measured in dollars per bushel were smaller during 1997-2002 than during 1974-1981, 1982-1990, and 1991-1996 (see table 1). Oats has a smaller standard deviation during 1974-1981 while soybeans has a smaller standard deviation during 1991-1996. Standard deviations for 1997-2002 were essentially the same as the standard deviations for soybeans during 1974-1981 and for oats during 1991-1996. The same general picture of smaller standard deviations during 1997-2002 emerges when the standard deviation of the change in ln annual price is examined (see table 1). Exceptions are the smaller standard deviations for oats and sorghum during 1974-1981 and for oats, soybeans, and wheat during 1991-1996. Despite the skewness toward lower standard deviations during 1997-2002, none of the standard deviations, whether measuring absolute or relative price variability, differed by an amount that was statistically significant at the 90% confidence level.

F-tests also were conducted on the differences in the standard deviations calculated for 1974-1981, 1982-1990, and 1991-1996. No statistically significant differences at the 90% confidence level were found. Given this result, standard deviations were calculated for the longer time period of 1974-1996. Using the level of annual price, all standard deviations were smaller during 1997-2002 than during 1974-1996 (see table 1). In contrast, when using the change in ln of price, three standard deviations were smaller during 1974-1996 and three were smaller during 1997-2002. No statistically significant differences were found at the 90% level of confidence.

Pearson correlations of the change in ln of annual price for each time period are presented in table 2. As expected, all correlations were positive. Most exceeded 0.5. Of the 15 correlations estimated, at least 11 were higher during 1997-2002 than during each of the three earlier time periods (see table 3). Thus, at least 11 of the differences had a positive sign. Examined from a somewhat different perspective, the 15 correlations averaged 0.84 for 1997-2002, compared with 0.61 for 1974-1981, 0.72 for 1982-1990, and 0.67 for 1991-1996 (see table 2).

The non-parametric sign test revealed that Pearson correlations were statistically higher during 1997-2002 than during 1974-1981 at the 93% level of statistical confidence (see table 3). However, the degree of statistical confidence for the other two comparisons was only 86%, which falls below the conventional level of 90% needed to conclude that the correlations were statistically higher during 1997-2002 than during either 1982-1990 or 1991-1996.

Similar to the previous findings regarding the mean and standard deviation, the sign test of the Person correlations estimated for 1974-1981, 1982-1990, and 1991-1996 revealed that the correlations did not differ statistically from each other at the 90% level of statistical confidence (see table 3). Thus, correlations were estimated for the 1974-1996 period. Eleven of these correlations were smaller than the correlations estimated for 1997-2002. However, the

sign test did not indicate that the Pearson correlations for these two periods were statistically different at the 90% level of confidence.

Among the individual crops, correlations have increased the most during 1997-2002 for soybeans and wheat. For example, compared with 1974-1996, the average of all five possible correlations during 1997-2002 was higher by a difference of 0.33 for soybeans and 0.29 for wheat (see table 2). Of particular note, the correlation between soybeans and wheat increased by 0.70.

Summary, Conclusions, Implications

Before discussing conclusions and implications, it is important to emphasize the small number of observations available for this study. A small number of observations results in the statistic procedures having a low power to determine significant differences. Thus, the findings of this study may change substantially as more years are added to the analytical data base. Nevertheless, managers and policy makers need information about potential on-going changes in order to make more informed decisions as well as to formulate key questions that need monitoring.

This analysis of the annual crop year prices of barley, corn, oats, sorghum, soybeans, and wheat since 1974 finds that the average price of corn and soybeans has declined after the passage of the 1996 farm bill by a statistically significant amount. In contrast, the average annual price of the four other Midwestern field crops is not statistically different between the pre- and post-1996 farm bill periods. These findings are related in part to the changes in harvested acres that have occurred following the 1996 farm bill's elimination of the annual acreage set aside program. Harvested acres of soybeans averaged 21% more for the 1997-2002 crops than for the 1991-1995 crops (USDA, National Agricultural Statistics Service, February 2002). Acres of corn harvested for grain also increased by 4%. In contrast, acres harvested of oats,

barley, sorghum, and wheat declined by 40%, 28%, 15%, and 12%, respectively. An increase in acres translates into a larger supply and thus lower price, everything else equal.

Everything else constant, the lower average price for corn and soybeans when combined with the evidence that the price of the other four crops have not increased suggests that the cost of government programs will be higher in the future. Furthermore, the average price of soybeans over the 1997-2002 crop years ($5.06/bushel) almost equals the national marketing loan rate set by the 2002 Farm Bill ($5.00/bushel) (USDA, March 2002). Because the marketing loan rate effectively is a minimum on per unit gross return, this relationship suggests that future increases in U.S. soybean acres will be limited unless the price of soybeans increases. In fact, acres planted to soybeans in the U.S. have changed little since the 1999 crop year, remaining approximately 74 million acres (USDA, February 2002).

This study finds that the variability of annual cash price has not changed since the 1996 Farm Bill was enacted. Despite the low power of the tests conducted in the study, this conclusion is consistent with Natcher and Weaver's conclusion reached using conditional volatility estimates of corn and wheat prices (Natcher and Weaver, 2000; and Weaver and Natcher, 2000).

The correlations among annual crop prices in 1997-2002 are not statistically different from the pre-1997 periods except for 1974-1981. However, the findings that 11 of 15 correlations are more positive during 1997-2002 than during 1974-1996 and that the average correlation increased by 29% between these two periods imply that the price correlations bear close watching by farm and agribusiness managers as well as by policy makers. If additional data confirm that these correlations have increased by a statistically significant amount, then the common strategy of reducing risk by using these crops in rotation with each other has declined in value. Given the prevalence of crop rotations in the Midwest, the consequence of such a finding will be a greater risk of farming in the U.S. Midwest, everything else constant.

Footnotes

1. Zulauf and Blue (2003) calculate the implied price volatility derived from the premium value of the corn and soybean harvest futures option traded during the spring preceding harvest. They find that it has been higher after 1996 at the 95 percent level of statistical confidence. This finding suggests that the market believes that price volatility may ultimately increase over the growing season. On the other hand, Zulauf and Blue find no consistent statistical evidence that the implied price volatility derived from the premium value of the corn and soybean May option during the preceding fall has increased after 1996. This finding suggests that the market does not expect post-harvest price volatility to increase.
2. Because the 1996 farm bill was signed into law during April 1996 (U.S. Department of Agriculture, Economic Research Service, 1996), planting decisions already had been made for the 1996 winter wheat crop and were underway or completed for other crops. Thus, the 1996 crop year is considered a transition year and is included with the 1991 farm bill period.
3. Annual acreage set asides were never authorized by a farm bill for soybeans.
4. For a discussion of the impact of the flex acre provision on planted acreas of program crops, see Zulauf and Tweeten (1996).
5. The marketing loan repayment option first appeared in the *Food Security Act of 1985*, which mandated this option for cotton and rice. It gave the Secretary of Agriculture discretionary authority to implement marketing loans for feed grains, soybeans, and wheat (Glaser, 1986).

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Table 1. Descriptive Statistics for Crop Year Annual Price of Major Midwest Field Crops during Selected Time Periods, U.S., 1974-2002.

	Time Period				
Statistic by Crop	1974-1981	1982-1990	1991-1996	1974-1996	1997-2002
Panel A: Mean Annual Price ($/bushel)					
Barley	2.34	2.19	2.30	2.27	2.25
Corn	2.51**	2.36	2.53*	2.45**	2.05
Oats	1.47	1.56	1.46	1.50	1.38
Sorghum	2.31*	2.11	2.35	2.24	1.94
Soybeans	6.36**	5.99*	6.18**	6.17**	5.06
Wheat	3.39	3.16	3.63*	3.37	2.92
Panel B: Standard Deviation of Annual Price ($/bushel)					
Barley	0.37	0.36	0.40	0.36	0.26
Corn	0.39	0.47	0.41	0.42	0.25
Oats	0.26	0.44	0.30	0.34	0.30
Sorghum	0.37	0.41	0.44	0.40	0.30
Soybeans	0.78	1.00	0.77	0.85	0.78
Wheat	0.64	0.51	0.63	0.59	0.46
Panel C: Standard Deviation of Change in Natural Logarithm of Annual Price (%)					
Barley	16.9	21.6	17.0	17.5	13.9
Corn	17.5	24.5	23.6	20.0	14.4
Oats	19.3	34.0	15.6	24.4	26.7
Sorghum	18.3	21.4	29.0	20.4	19.8
Soybeans	23.1	23.2	14.0	19.5	17.1
Wheat	20.0	21.6	12.6	18.1	18.4

* and ** indicates that the statistic for the period is statistically different than the comparable statistic for the 1997-2002 period at the 90 percent and 95 percent confidence level, respectively. The null hypothesis is that the statistic does not differ between the two periods.

Source: Original Computations using data collected from the U.S. Department of Agriculture

Table 2. Pearson Correlation of Change in Natural Logarithm of Crop Year Annual Price of Major Midwest Field Crops during Selected Time Periods, U.S., 1974-2002.

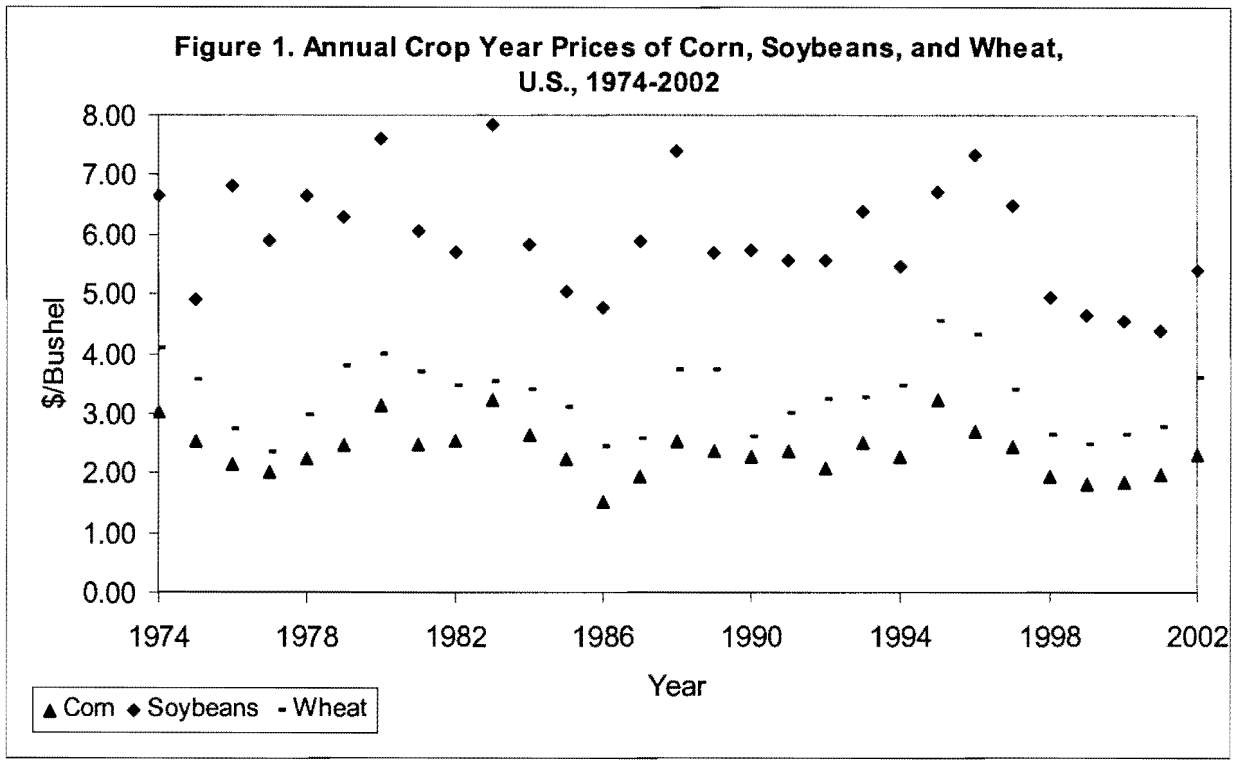
	Time Period				
Crop Pair	1974-1981	1982-1990	1991-1996	1974-1996	1997-2002
Corn-Soybeans	0.444	0.783	0.703	0.636	0.949
Corn-Wheat	0.735	0.664	0.720	0.664	0.986
Corn-Sorghum	0.983	0.976	0.986	0.967	0.909
Corn-Barley	0.837	0.843	0.793	0.806	0.898
Corn-Oats	0.413	0.550	0.518	0.477	0.797
Soybeans-Wheat	0.079	0.395	0.332	0.276	0.979
Soybeans-Sorghum	0.457	0.743	0.579	0.558	0.882
Soybeans-Barley	0.510	0.735	0.485	0.624	0.942
Soybeans-Oats	0.484	0.691	0.828	0.621	0.610
Wheat-Sorghum	0.770	0.674	0.754	0.655	0.918
Wheat-Barley	0.763	0.860	0.943	0.813	0.893
Wheat-Oats	0.441	0.634	0.558	0.577	0.683
Sorghum-Barley	0.894	0.875	0.790	0.793	0.768
Sorghum-Oats	0.478	0.596	0.403	0.443	0.616
Barley-Oats	0.805	0.827	0.671	0.786	0.714
Average	0.606	0.723	0.671	0.647	0.836

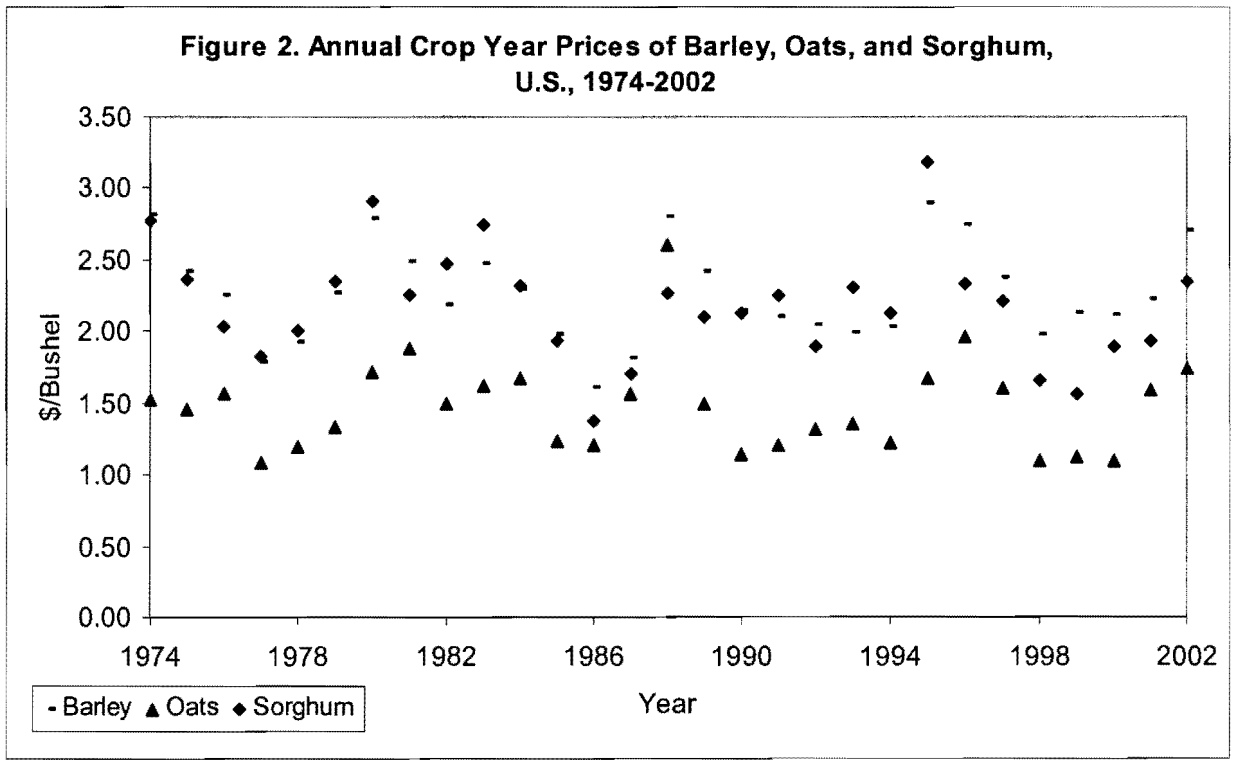
SOURCE: Original Computations using data collected from the U.S. Department of Agriculture.

Table 3. Sign Test for Differences in Pearson Correlations Between Selected Time Periods, U.S., 1974-2002.

	1982-1990 vs. 1974-1981	1991-1996 vs. 1974-1981	1991-1996 vs. 1982-1990	1997-2002 vs. 1974-1981	1997-2002 vs. 1982-1990	1997-2002 vs. 1991-1996	1997-2002 vs. 1974-1996
Total number of correlations	15	15	15	15	15	15	15
Correlation higher in later period	11	8	5	12	11	11	11
z-value	1.46	0.37	-1.10	1.83	1.46	1.46	1.46
Confidence level	86%	29%	73%	93%	86%	86%	86%

Source: Original Computations using data from Table 2.





Source: Data from U.S. Department of Agriculture